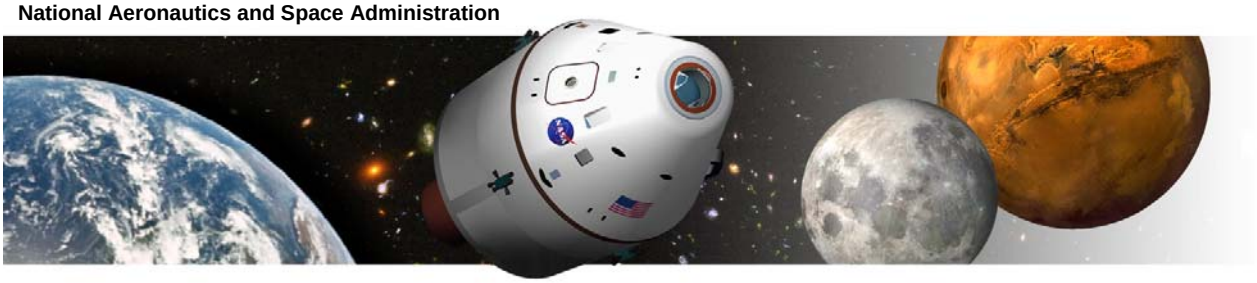
National Aeronautics and Space Administration



Spacesuits: Pressurized Protection from Thermal Effects

9-12 National Science Standards:
Physical Science: Investigating Pressure and Temperature

Summary:
Astronauts wear a "personal spacecraft" each time they go on a space walk. NASA's spacesuits contain all the necessary life support systems an astronaut needs to survive for up to 8 hours in the harsh extreme environment of space. This video and accompanying information provide an exciting means of reinforcing pressure and temperature concepts in the classroom.

Featured Imagery Component:
NASA 60 second Brain Bites feature, "How Do You Scratch Your Nose in a Spacesuit?" To view this clip, please visit: http://brainbites.nasa.gov/scratchyournose/

Post-Video Discussion:

1. What is the atmospheric pressure in space?
2. How does the pressure within a spacesuit compare to that of a spacecraft and to Earth?
3. Why do spacesuits need to contain their own oxygen supply?
4. Why do astronauts need to pre-breathe oxygen before undergoing a spacewalk?
5. Why do spacesuits need to have so many layers? Why are the suits white?
6. What is the difference in temperature between direct sunlight and shade that astronauts are exposed to in space? How is it possible for an astronaut to experience both extreme temperatures at the same time?
7. Why is it important for spacewalking astronauts to keep cool? How do their suits help them to do so?
8. Why do spacewalking astronauts need to wear gloves? Why do the gloves have different layers?
9. How do the gloves work to keep a spacewalking astronaut's hands warm?
10. How are the heaters in spacesuit gloves and in the "helmet cam" powered?

To learn more about spacesuits, go to http://www.nasa.gov/education/spacesuits.

1. Space is nearly a perfect vacuum. There is essentially no atmospheric pressure.
2. The air pressure in a spacesuit is (29.6 kilopascals of 100% oxygen, or 4.3 pounds per square inch) less than both in a spacecraft and at sea level on Earth (101 kilopascals, or 14.7 pounds per square inch).
3. Humans need oxygen to breathe. Since there is no oxygen in space, the spacesuit must contain an oxygen supply. NASA's spacesuits contain four oxygen tanks filled to 3.5-4.0 psi of 100% oxygen.

4. Before leaving the spacecraft to perform tasks in space, an astronaut has to spend several hours breathing pure oxygen before proceeding into space. This procedure is necessary to remove nitrogen dissolved in body fluids and thereby to prevent its release as gas bubbles when pressure is reduced, a condition commonly called decompression sickness or "the bends."

5. Spacesuits must keep astronauts cool when in the sun, and warm when in the shade. Suits have nine layers in some places that help protect against thermal extremes and a host of other space-related hazards. Astronauts use white spacesuits when they go on spacewalks to do work outside the space shuttle or International Space Station. White was chosen for a few reasons. One of the most important reasons is that white reflects heat so that the astronaut doesn't get too warm. Astronauts can get too cold as well, especially in their hands. Therefore, the spacesuits have heaters in their gloves. Another reason spacewalkers use white spacesuits is that white is visible against the black background of space, so other astronauts can easily see the spacewalker. In addition, since spacewalking astronauts always go out in pairs, one of the suits always has red stripes in four places so the other astronauts can tell one spacewalker from the other.

6. In space, the temperature difference between sun and shade can be nearly 135 degrees Celsius. This difference can exist between the front and back of a suit, depending on the direction the astronaut is facing.

7. Spacesuits must keep astronauts cool so they don't overheat or sweat as condensation from sweating can fog up the visors and limit their vision. Astronauts wear an undergarment of liquid-filled tubes that remove heat to keep them cool.

8. Astronauts must wear gloves to protect themselves while on spacewalks. NASA's gloves have 3 primary layers. From the outside layers in are: the Thermal Micrometeoroid protection Garment (TMG), the Restraint, and the Bladder. The TMG provides thermal insulation and some protection against micro meteoroids or orbital debris. The Restraint carries the internal pressure loads and uses hard surfaces to improve hand mobility. Finally, the Bladder is the layer that keeps the suit sealed and prevents precious oxygen from escaping.

9. In addition to maintaining pressure, NASA's spacesuit gloves also work to keep astronauts' hands warm. Unlike ordinary gloves, NASA's contain heaters that are attached to the inner surface of the TMG. These heaters are purposely placed outside the suit's bladder because any sort of spark or short circuit in the pure oxygen environment could start a fire. For this reason, there is only one electrical harness inside the Bladder and it is used to carry only very low-powered signals. One of the signals carries biomedical information (basically heart rate data) to the radio to be transmitted to flight surgeons in Houston's Mission Control center. The other signal simply carries voice communication signals between the astronaut and his radio.

10. The heaters in spacesuit gloves, along with the ERCA (Extravehicular mobility unit Radio frequency Camera Assembly) or "helmet camera" are powered by the Rechargeable Extravehicular Battery Assembly (REBA). The REBA is designed to provide 12.5 +/- 1.5 volts from 50 small rechargeable Nickel Metal Hydride (NiMH) batteries. Between the REBA and the heaters is another important component called the In-Line Cable Voltage Regulator (ILCVR). The ILCVR reduces the 12 volt source down to 9 volts for the glove heaters, whereas the ERCA requires 12 volts. Given that the gloves' heaters have a resistance of 57.7 +/- 2.9 ohms and a nominal voltage of 9 volts, challenge your students to calculate the nominal current drawn by the glove heaters (~0.156 amperes). Remind them that voltage, $\boldsymbol{V}$, is related to current, $\boldsymbol{I}$, and resistance, $\boldsymbol{R}$, through the equation $\boldsymbol{V} = \boldsymbol{I}*\boldsymbol{R}$. Similarly, consider having them calculate the power, $\boldsymbol{P}$, consumed by the glove's heaters using the relationship $\boldsymbol{P} = \boldsymbol{I}*\boldsymbol{V} = \boldsymbol{I}^2*\boldsymbol{R}$ (~1.4 watts).

Suggested Activities:

Living in Space
http://www.nasa.gov/audience/foreducators/nasaeclips/launchpad/living-in-space.html

Overview: The "Cooling Off" educator guide is an example for teachers in grades 9-12 to effectively use video segments as an instructional tool. Students are introduced to the challenges of maintaining temperatures while living in space. Thinking and acting like scientists and engineers, students experiment to learn how to measure the specific heat capacity (or simply, specific heat) of water and then design an improved cooling system.

Cooling Off Educator Guide
http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/guides.html

Radiation Budget Lesson: Exploring Albedo
http://eosweb.larc.nasa.gov/EDDOCS/scierbe.html

Concepts:

- Albedo is the percentage of incoming sunlight that is reflected, rather than absorbed.

Principles:

- Albedo is represented as a percentage of the Earth's total incoming energy. Thus, an albedo of 50% would indicate that half of all incoming radiation is reflected. Usually, the more radiation that is reflected the lower the overall surface temperatures.
- Albedo represents an important aspect of the radiation budget.
- The Earth Radiation Budget is a concept that uses the amount of energy the Earth gets from the sun and the amount of energy the Earth sends back to space. If the Earth receives more solar energy than it sends back to space, we expect the Earth to warm. If the Earth sends more energy than it receives from the Sun, we expect the Earth to cool.
- In general, more lightly-colored surfaces (snow and ice, for example) have a higher albedo than darker-colored ones (trees, blacktop roads, etc).

Suited for Spacewalking Educator Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Suited_for_Spacewalking_Educator_Guide.html

Overview: This NASA educator guide for grades 5-12 focuses on the technology behind spacesuits. Briefly discussed are the space environment, the history of spacewalking, NASA's current spacesuits and the work that astronauts do during spacewalks. This guide includes classroom activities, a glossary and a list of other NASA resources.

Keeping your Cool, page 71-73
Objective: To investigate and experience the way the water cooling system in the Space Shuttle EMU functions.

Absorption and Radiation, page 75-76
Objective: To investigate the effect different colors, reflective surfaces, and different materials on radiant heat absorption and heat radiation.

O_2- How much? page 83-84
Objective: To measure the quantity of oxygen a person will need under varying levels of activity

Keeping the Pressure On, page 85-86
Objective: To demonstrate one method for creating a workable pressure inside a spacesuit.

Additional Resources:

Spacesuit Evolution: From Custom Tailored to off the Rack:
http://history.nasa.gov/spacesuits.pdf

Borrow a Real Spacesuit:
http://www.nasa.gov/centers/johnson/events/exhibits/suits.html